The XENIA mission

Cosmic chemical evolution of baryons

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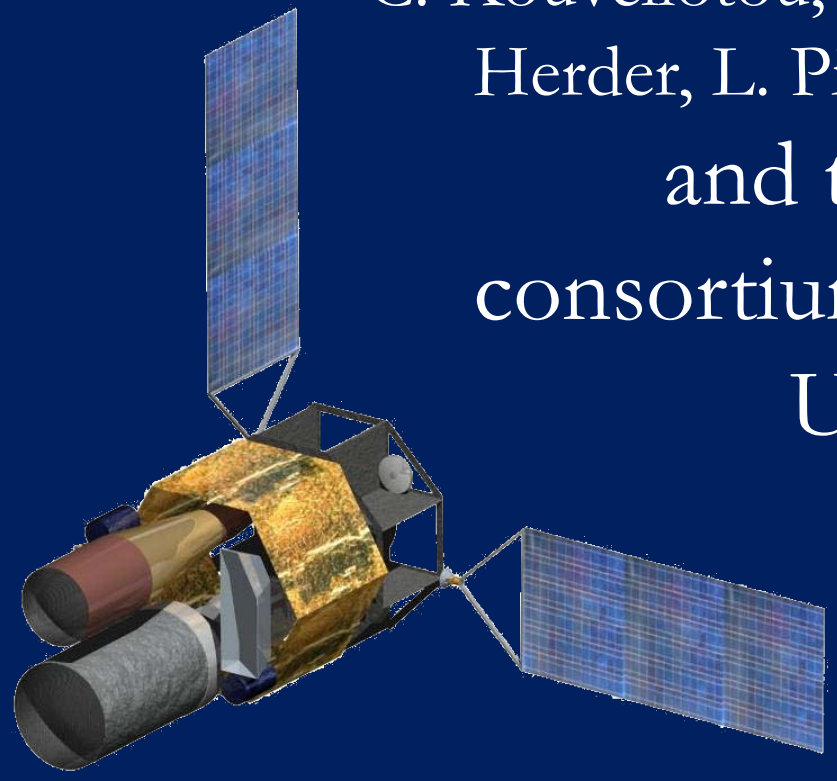
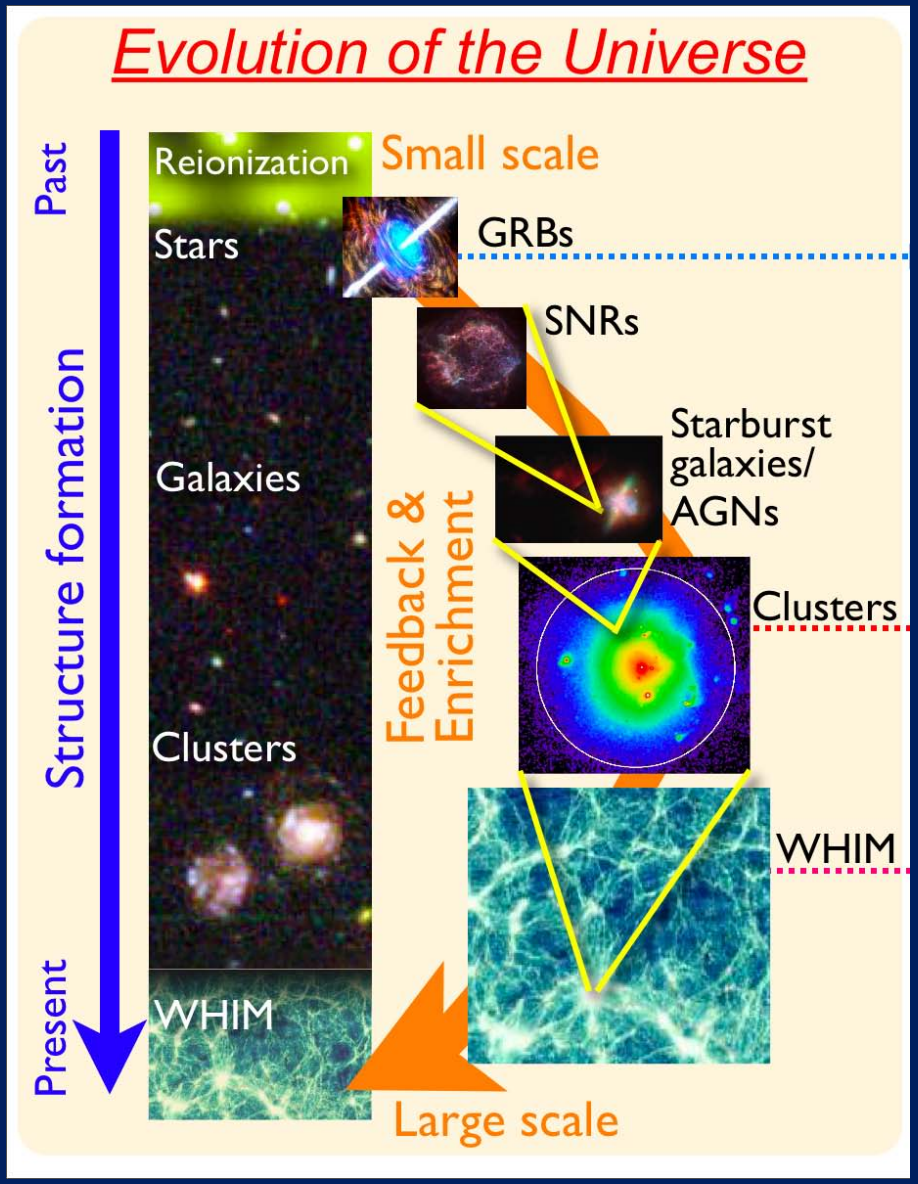
and the Xenia team:

consortium of Institutes from US, Eu, Japan



Xenia will trace structure formation



Gamma-Ray Bursts

- Evolution of massive star formation using GRBs to trace their explosions back to $z > 8$)
- Measure the metals in the host galaxies of GRBs and the explosive enrichment in their close environment out to $z>8$

Clusters of Galaxies

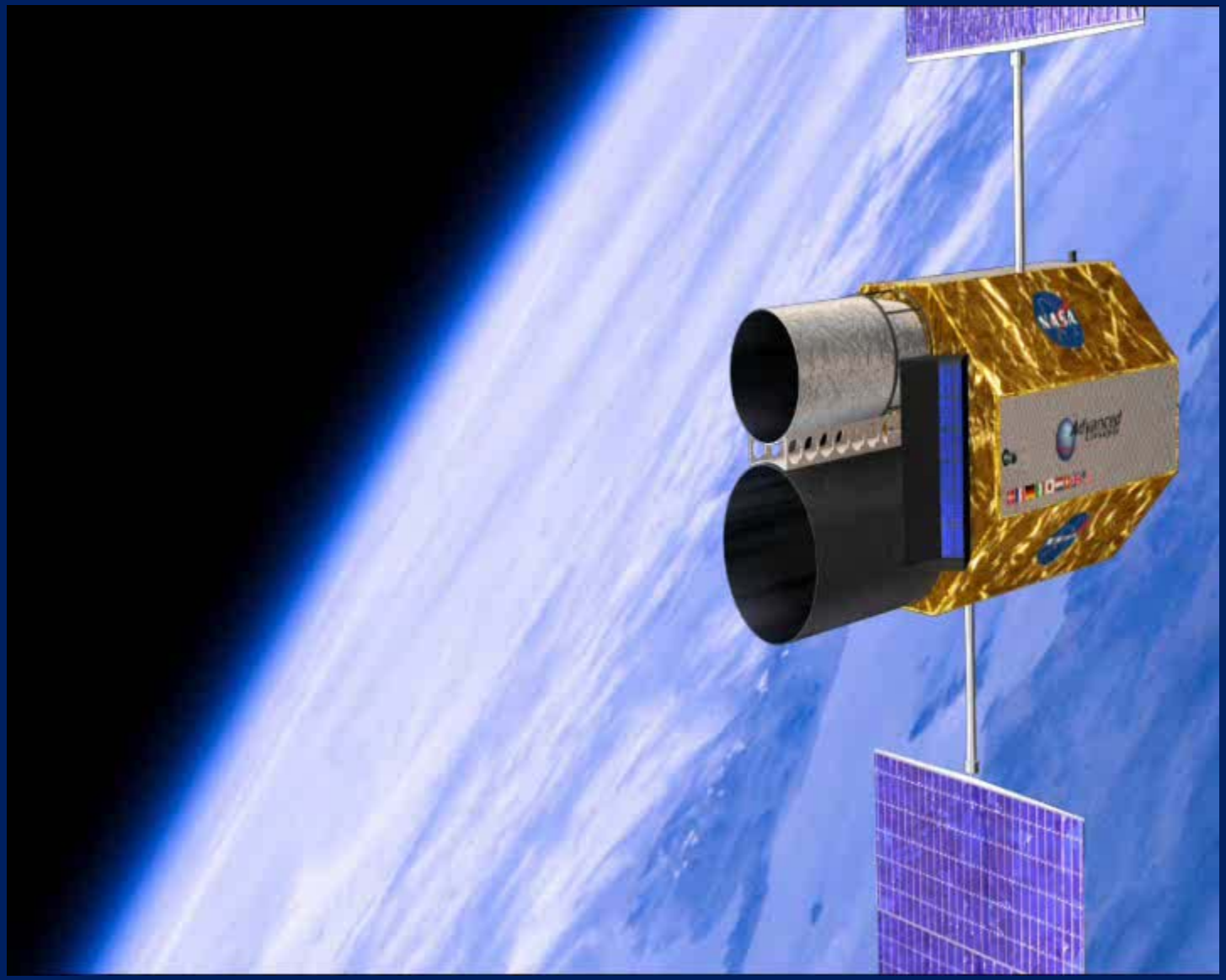
- Trace the evolution and physics of clusters out to their formation epoch ($z>1$)
- Measure the thermodynamical and chemical properties of a fair sample out to the virial radius

Cosmic Web

- Detect the largest reservoir of baryons from $z\sim1$ to the present time by measuring densities ~30 times smaller than previously done

Xenia mission profile

Xenia instruments

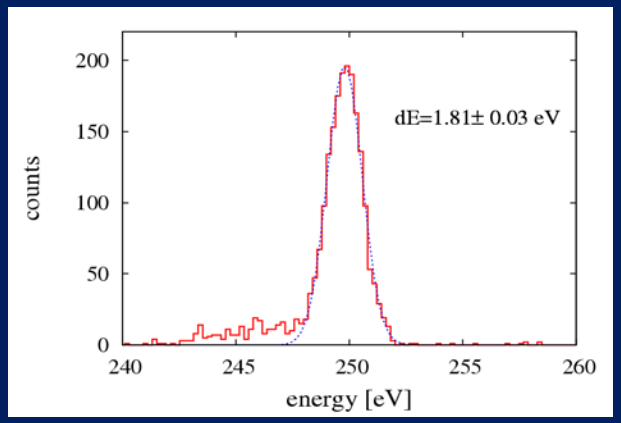


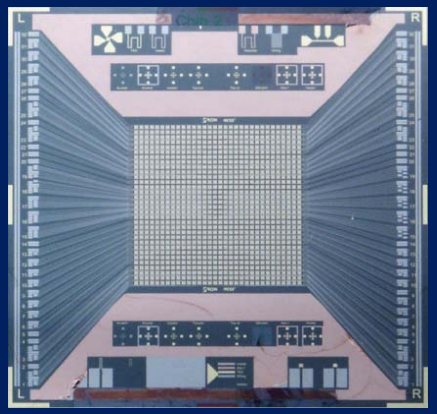
CRIS

Cryogenic Imaging Spectrometer

Area 1000cm^2@0.5keV
Energy range: 0.1-3 keV
Resolution: 2.5eV (1eV goal)
Field of view=1.0°
ang.res=3'

TES microcalorimeters



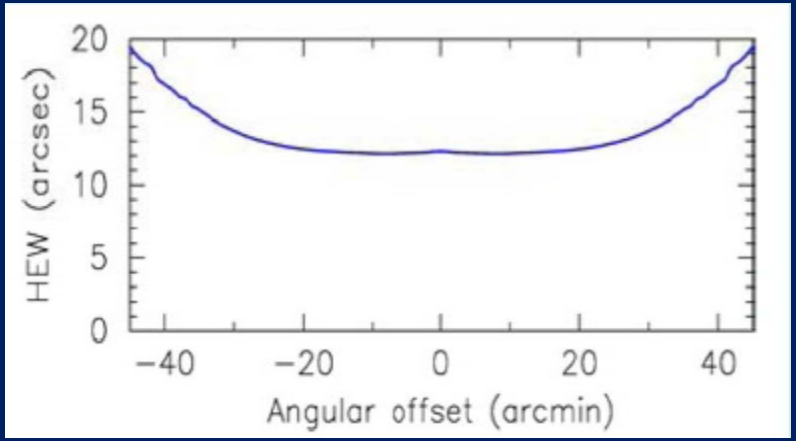


Xenia instruments

HARI

High Angular Resolution Imager

Area = 1000cm^2@1keV
Range: 0.3-8 keV
Field of view=1.4°
ang.res=10" constant
CCD



Xenia instruments

TED
Transient Event Detector

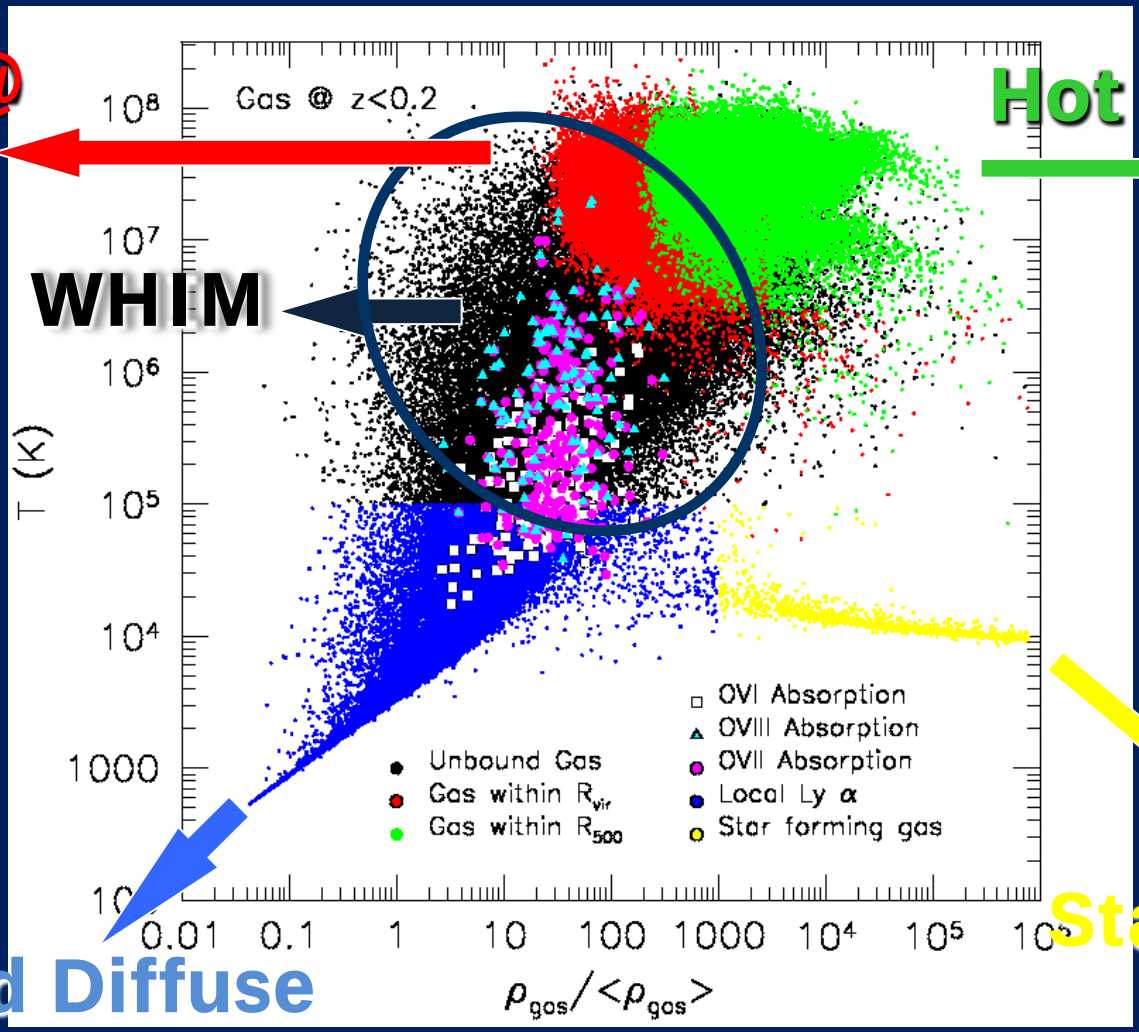
Eff area= 1500 cm2
8-200 keV (goal <5 keV)
3 sr (¼ of the sky,)
3' localization

2 CZT based coded mask detectors

GRBs as cosmological probes

- **TED: 150 GRB localized per year, 80 GRB with Fluence(15-150keV) > 10^{-6} erg cm-2 s-1**
- **GRB @ z>6: 7-14 (goal) per year**
- **Mid-bright GRB afterglow with a fast (t<60s) pointing CRIS yields 10^{5-6} X-ray photons, and 10^{3} cts in 1 eV resolution bin**
- **In 5 years: Golden sample of >250 afterglows with high resolution X-ray spectra: redshift, metals in host-galaxy and close environment from local to high-z universe**
- **Platinum sample of 150 afterglows for WHIM studies**

Exploring a new region of the Cosmic web



Cluster @ Virial r.

Hot (clusters)

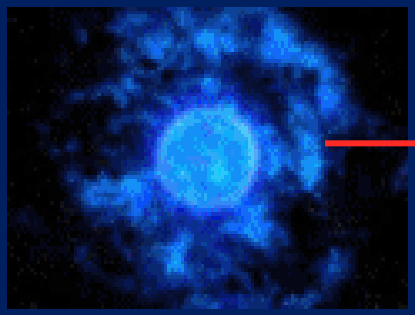
WHIM

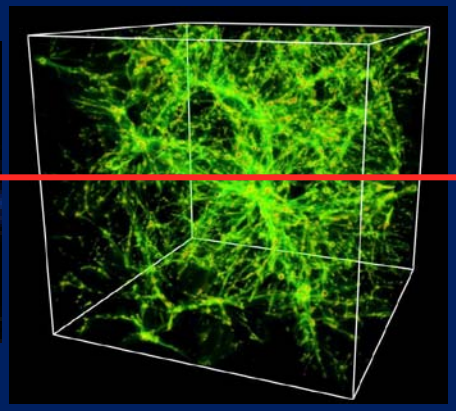
Cold Diffuse

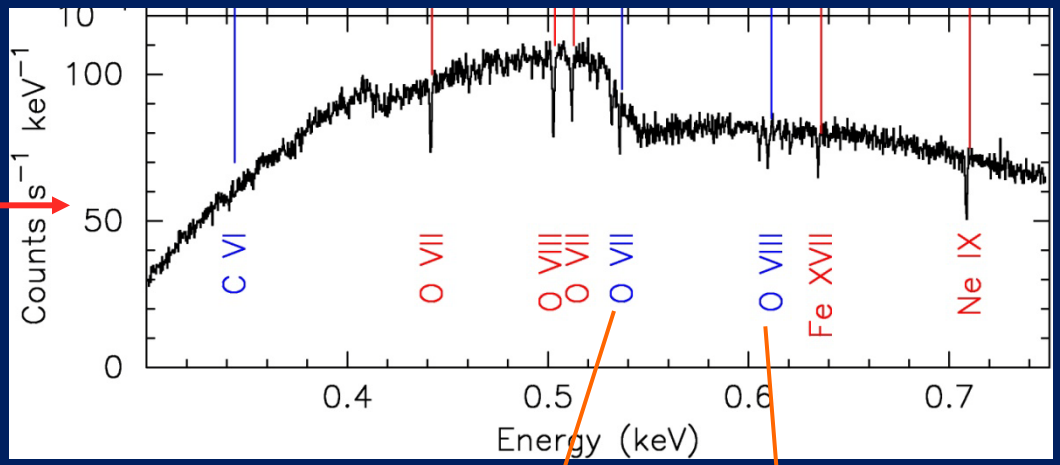
Star forming

Branchini et al 2009

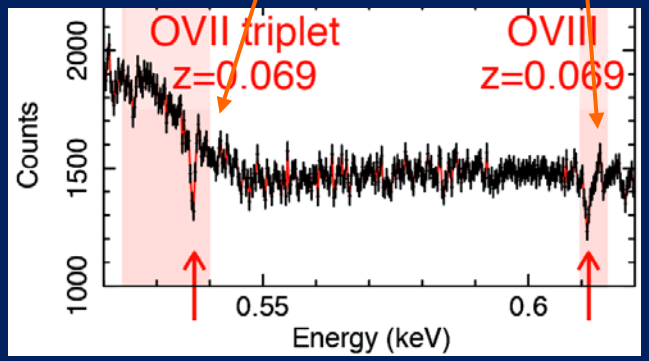
Tomography of the Universe: the X-ray forest from the Cosmic Web with GRBs







~200s OVII-OVIII filaments in 5 years

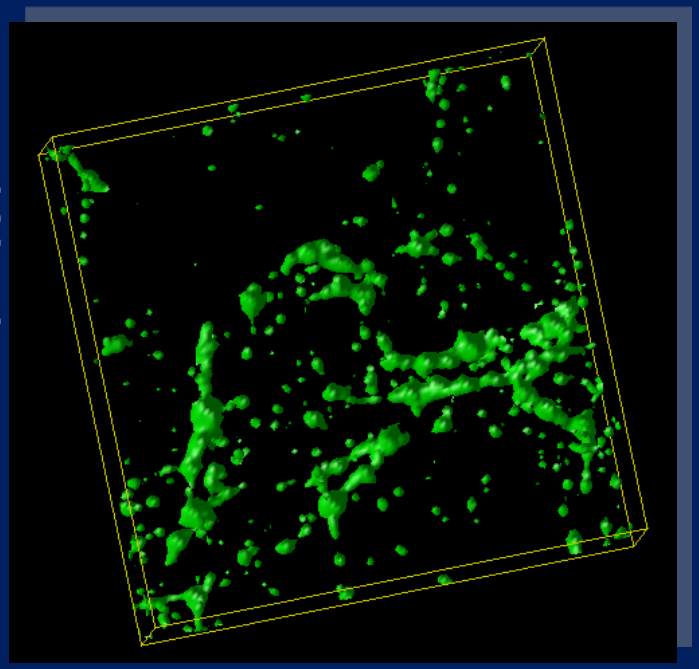


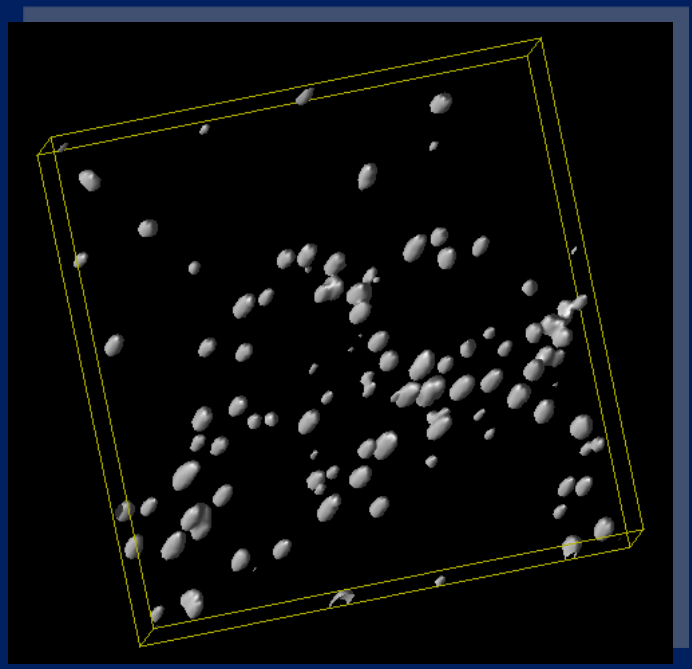
3D mapping of the Cosmic Web

Model, $\Delta z=0.01$

Detected, OVII+OVIII in emission, 5 σ, 1 Ms

4° x4°





Down to overdensities of 100

GRBs as cosmological probes

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- GRB @ z>6: 7-14 (goal) per year
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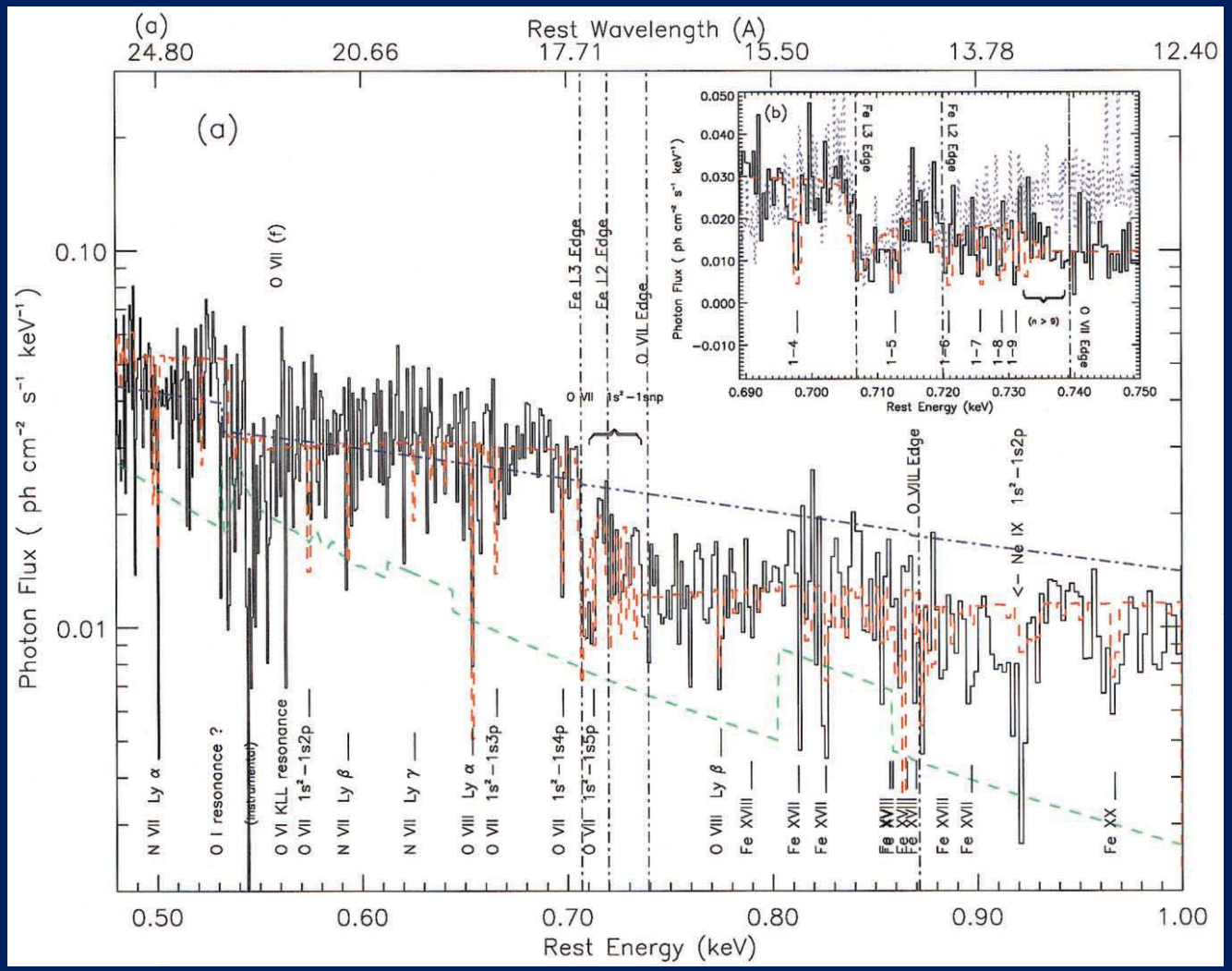
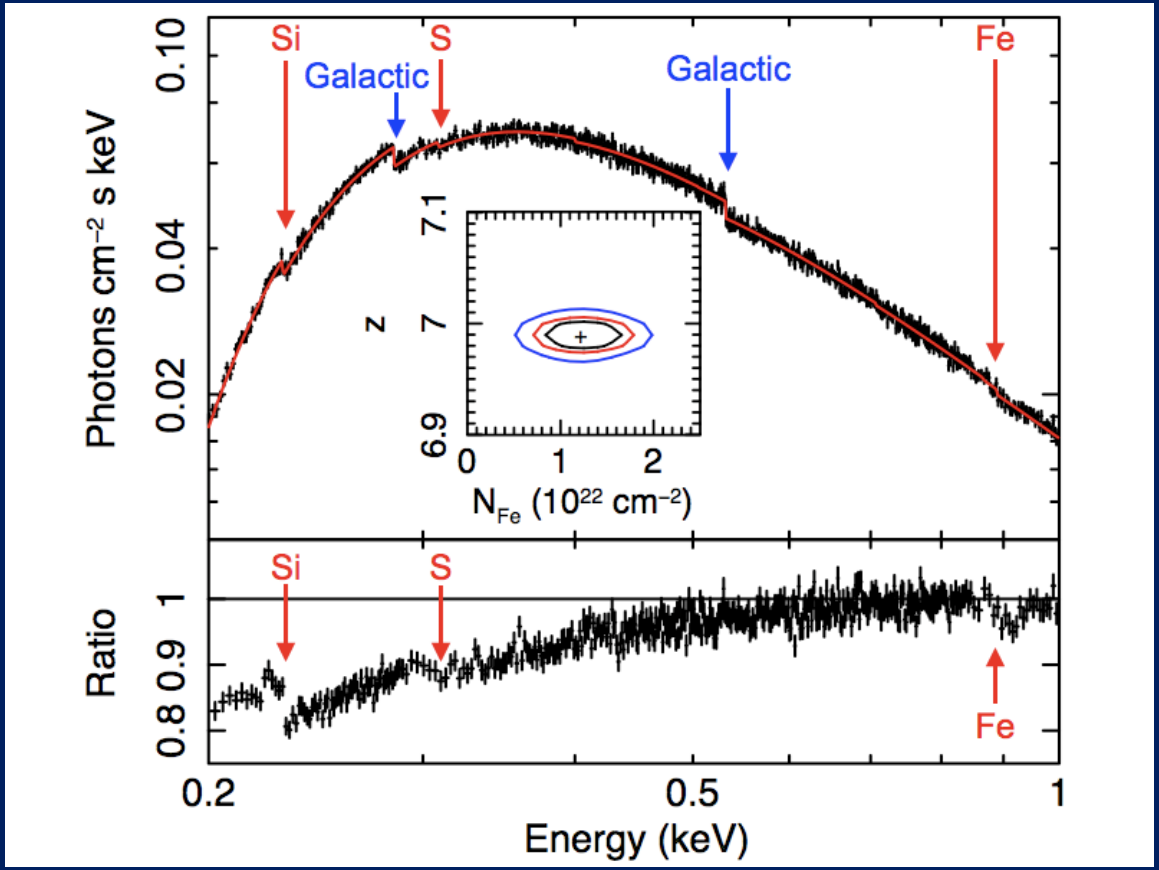
- Platinum sample of 150 afterglows for WHIM studies

Xenia X-ray spectrum of a GRB



MCG-6-30-15, Lee et al, Chandra HEGT 120 ksec

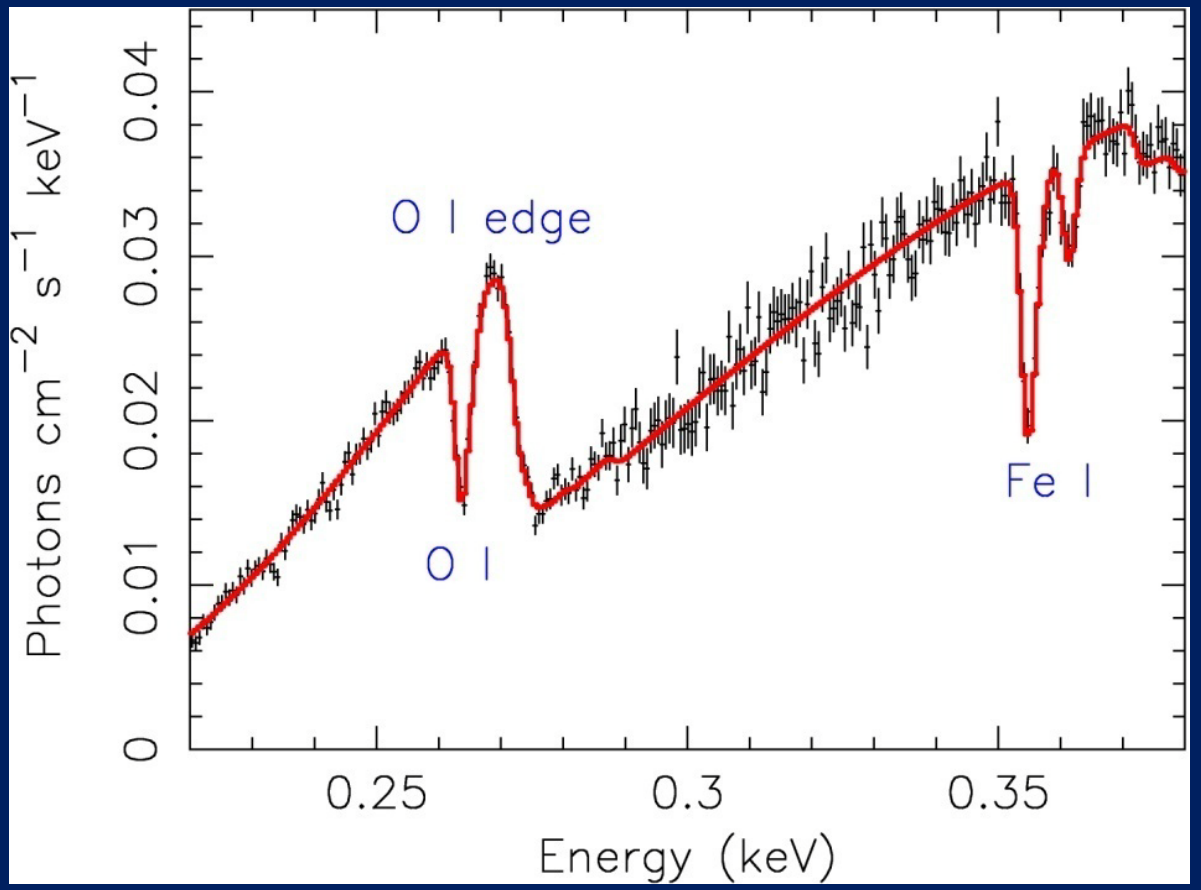
Tracing the metal enrichment in the GRB local environment



X-ray metal edges from a GRB nearby environment at z=7

ISM of the host galaxies

Chemical c., ionization, kinematics (outflows) in galaxies up to z>7



Resonant absorption lines from GRB host galaxy at z=1

Summary

- Medium class mission proposed to the 2010 Decadal Survey
- Xenia Unique capabilities: large grasp, fast reaction, high spectral resolution)
- Core science: GRB as probes, WHIM, clusters
- + Auxiliary science
- Brings in a large community outside GRBs

Cosmic Chemical Evolution Workshop
June 2-4, 2010 St. Michael's Maryland

(http://sms.msfc.nasa.gov/xenia/workshop.html)

SOC

Dieter Hartmann -- Chair
Tom Abel
Stefano Borgani
Joel Bregman
Dave Burrows
Renyue Cen
Martin Elvis
Jan-Willem den Herder
Chryssa Kouveliotou
Tiziana di Matteo
Neil Gehrels
Brad Gibson
Pat Henry
Jack Hughes
Jelle Kaastra
Francesca Matteucci
Takaya Ohashi
Luigi Piro
Xavier Prochaska
Sandra Savaglio
Volker Springel
Yasushi Suto

INVITED SPEAKERS:

Shirley Ho
Alex Heger
Jason Tumlinson
Serena Bertone
Takaya Ohashi
Grant Matthews
Art Champagne
Jelle Kaastra
Kyoko Matsushita
Neil Gehrels
Friedel Thielemann
David Burrows
Renyue Chen
Yoh Takei
Jochen Greiner
Volker Bromm
Andreas Burkert
Anna Frebel
Kazuhisa Mitsuda
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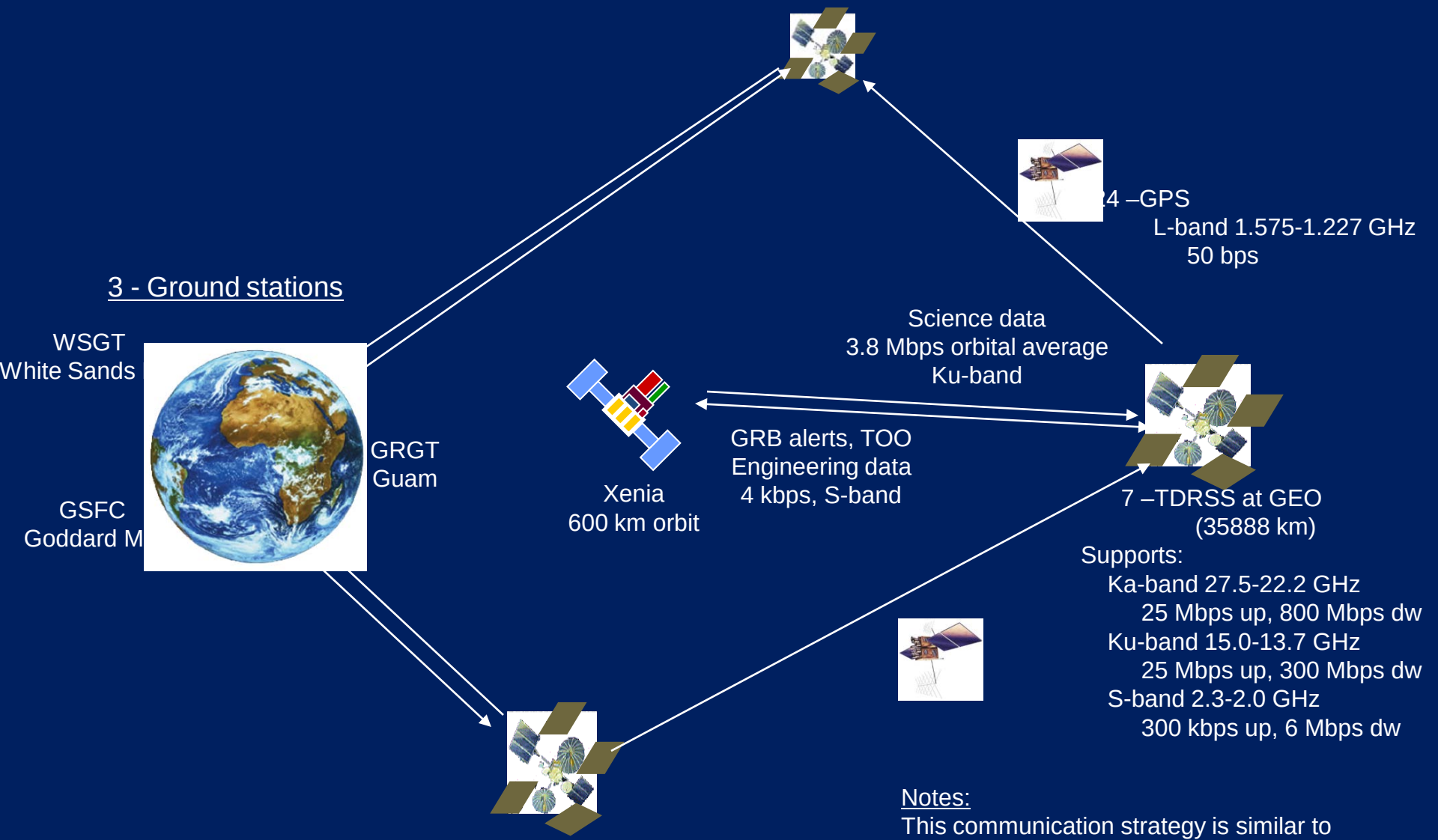
Eli Dwek
Thorsten Naab
Nobu Kawai
Christoph Pfrommer
J.-W. den Herder

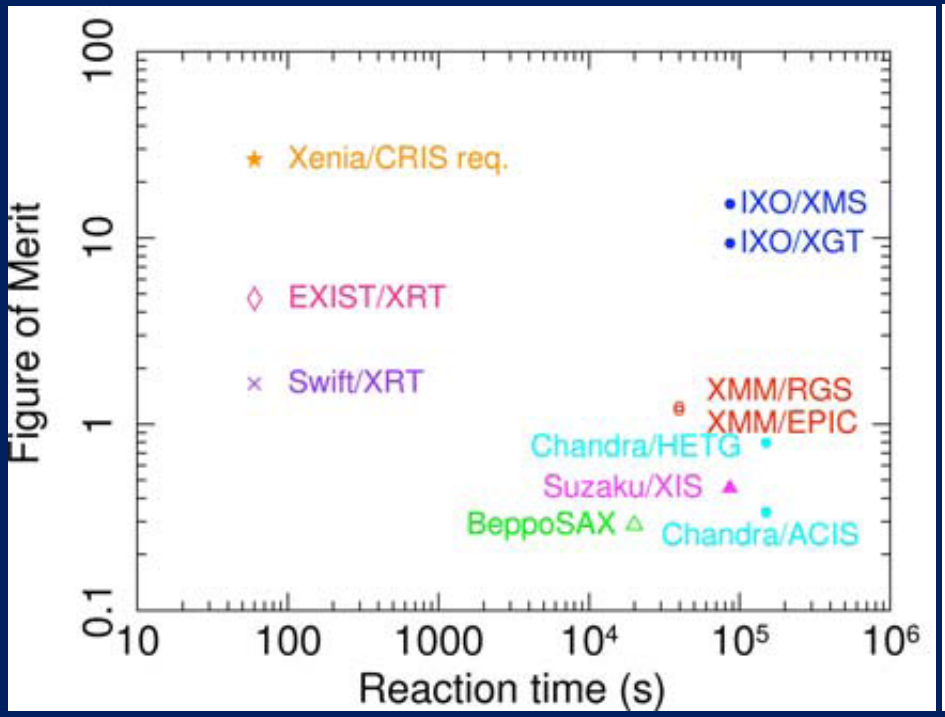
Avionics: Communication Strategy

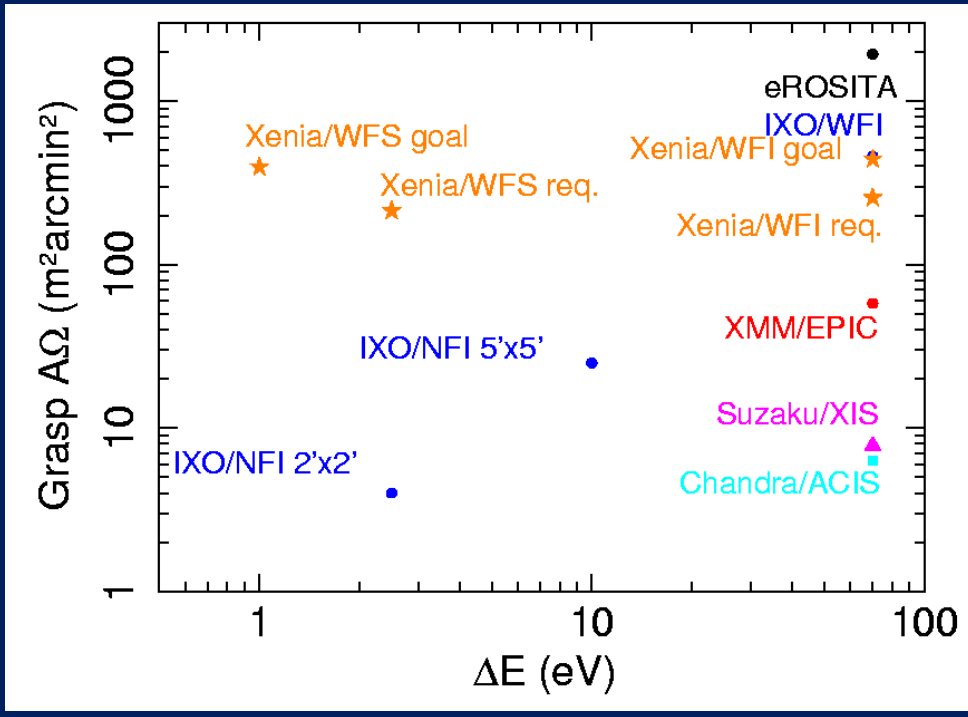


Notes:
This communication strategy is similar to FERMI (formerly GLAST), and suggested in EDGE.

Spectroscopy: fast reaction and wide field

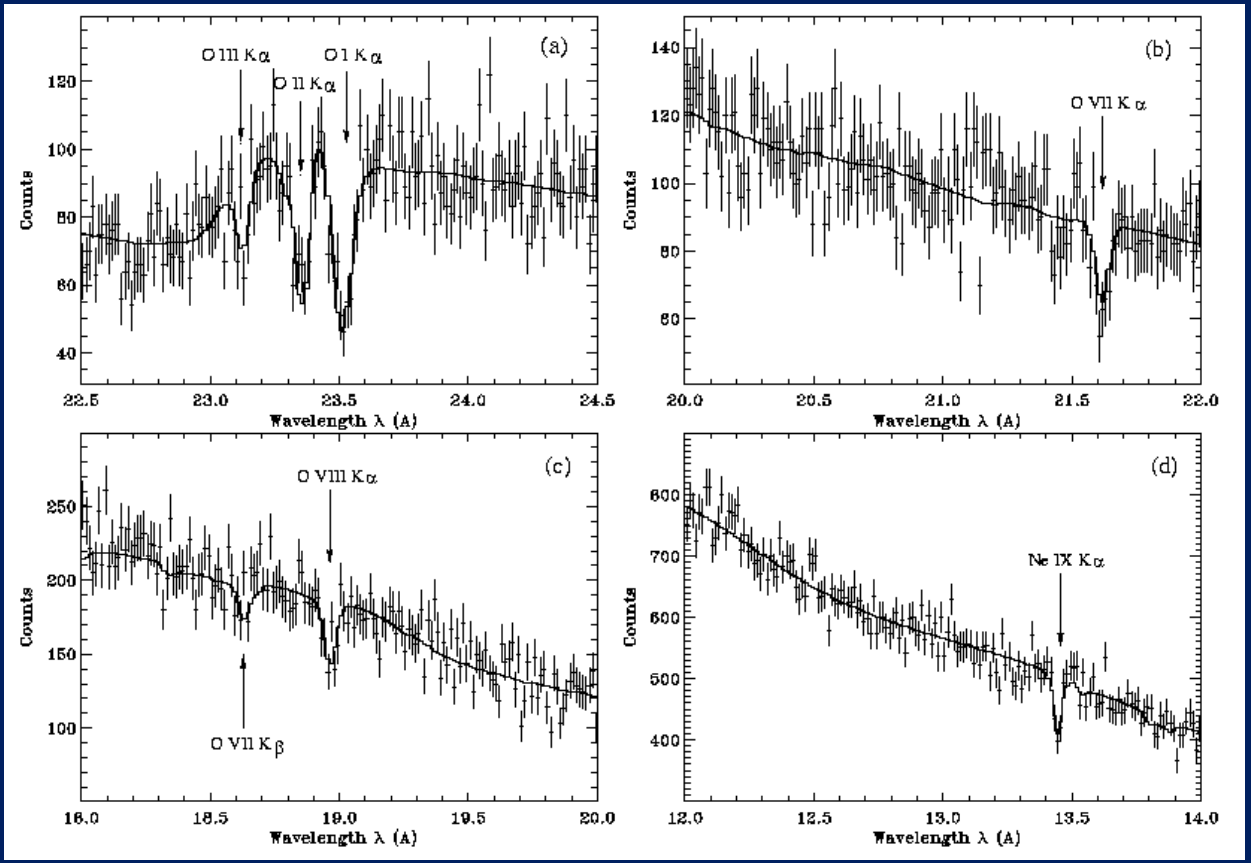
- Line spectroscopy merit factor for variable sources = S/N for EW=1eV for a typical GRB afterglow





X-ray Narrow abs lines from ISM in our own "host galaxy"

- Bright galactic binary (1820-303) observed with Chandra grating (Yao and Wand 2006)



Fast repointing

Requirement: < 65 sec for 80% GRB)

Ball Aerospace Worldview CMG

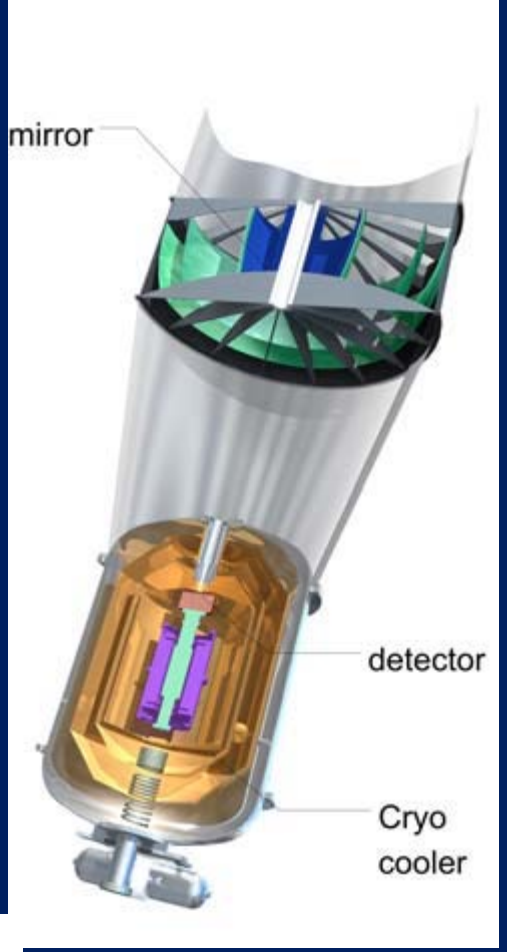
- Suggest using Ball Aerospace M-95 CMG 4 wheel pyramid configuration for all slews, station keeping, and observations.

- Provides up to 6.1 Nm torque (~4.0 Nm required for Xenia)

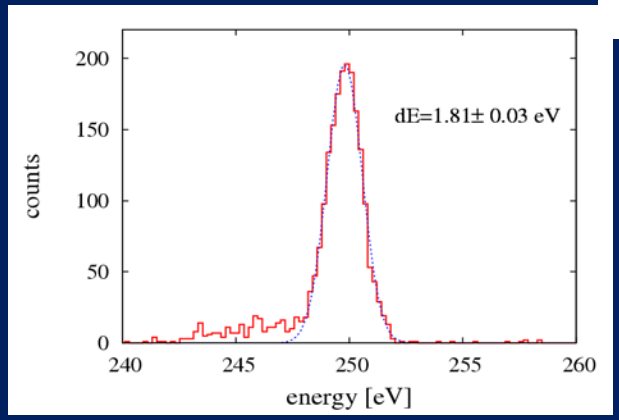
CRIS

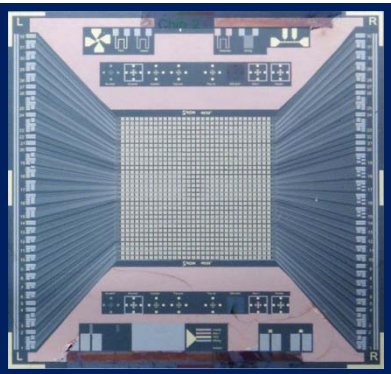
Table 5: CRIS Instrument Requirements

Parameter	Require-ment	Goal
Resolution at 0.5 keV	2.5 eV	1 eV
Field of View	0.9°×0.9°	1°×1°
Array size [pixels]	2000	2176
Energy range [keV]	0.2 – 2.2	0.1 – 3.0
Effective area @ 0.6 keV	1000 cm²	1300 cm²
grasp@0.6 keV [cm²deg²]	400	500
Angular resolution (HPD)	4 arcmin	2.5 arcmin
Peak count rate [c/s]	10,000	15,000



- Mirror: 2/4 reflection
- TES microcalorimeter

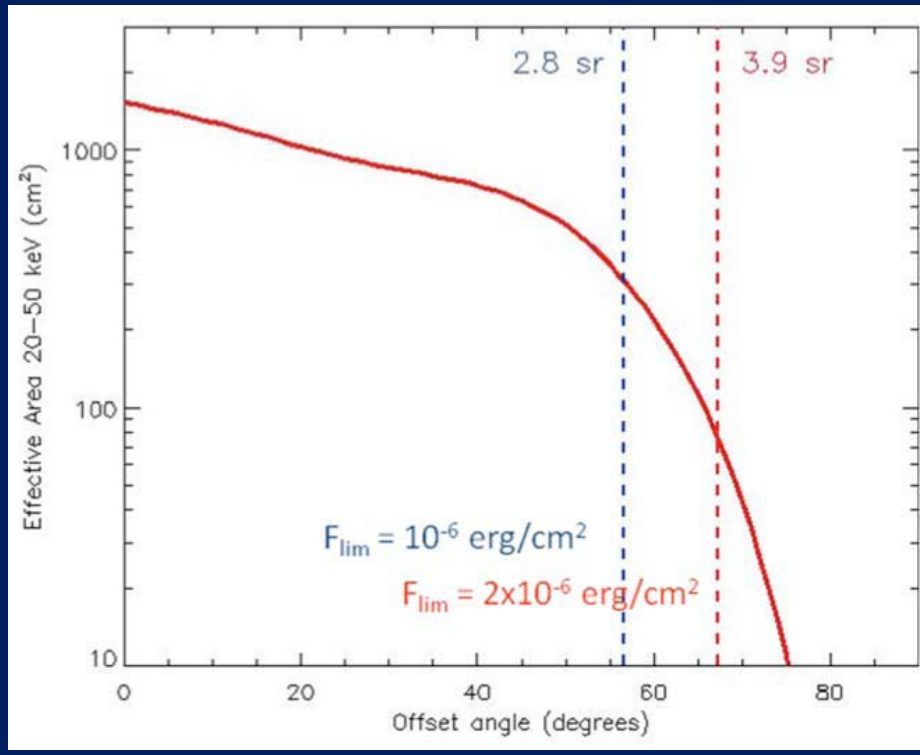




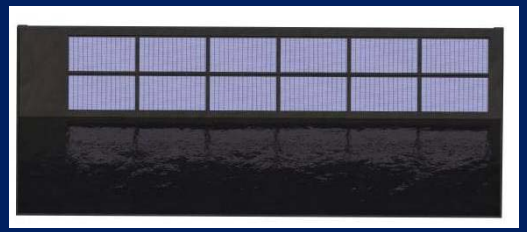
Transient Event Detector

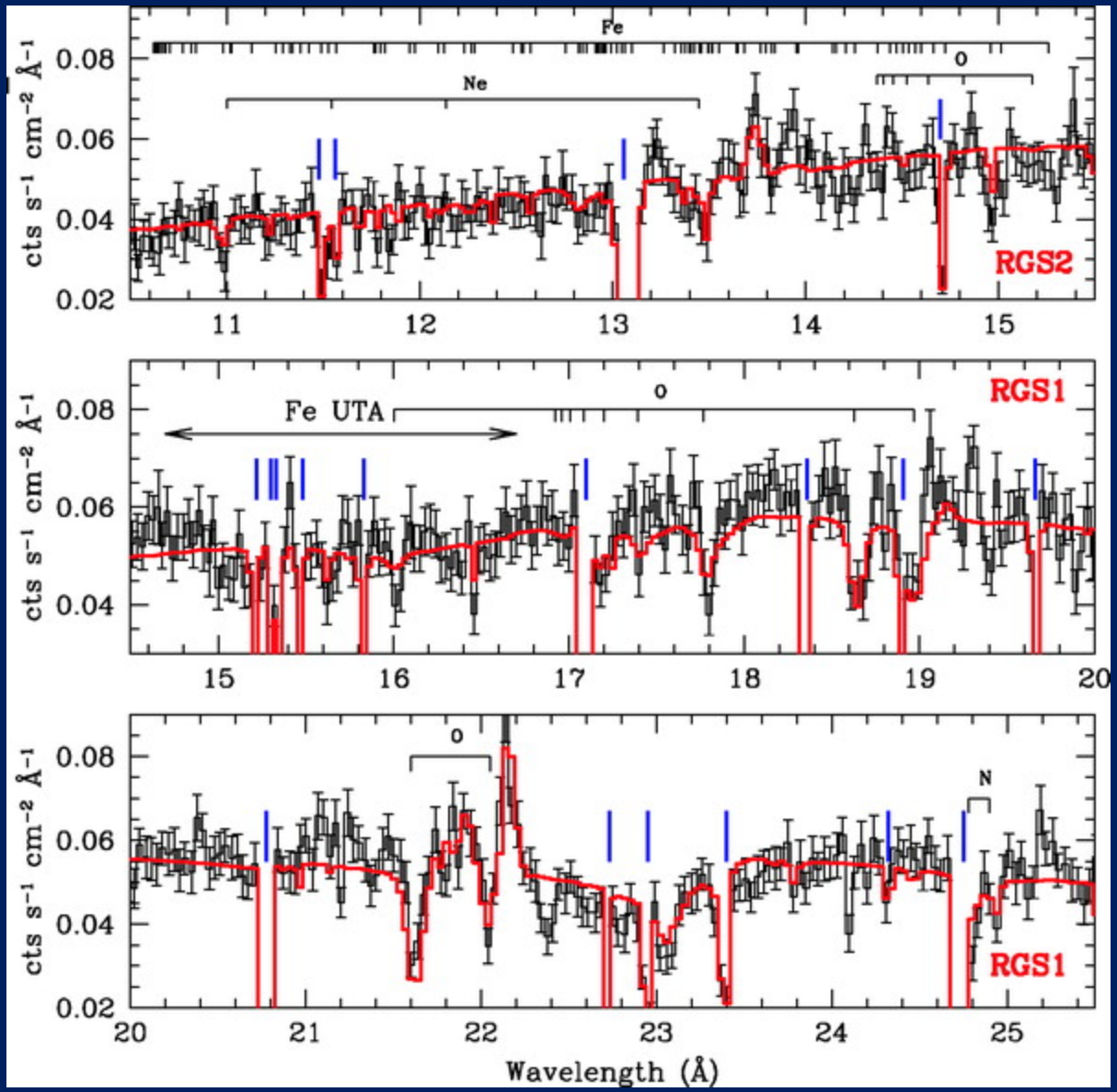
Table 3: TED Instrument Requirements

Parameter	Require-ment	Goal
Resolution at 100 keV	5 keV	3 keV
Field of View	2.8 sr	3 sr
Array size (pixels, one camera)	24,576	98,304
Energy range (keV)	8–200	5–300
Effective area, 20-50 keV (cm^2)	1500	1500
Angular resolution (FWHM)	34'	17'
Source location accuracy (10σ)	4'	2'
Min. count rate (background) [c/s]	2500	2500
Peak count rate [c/s]	7000	7000
S/W processing time	20s	10s
Continuum sensitivity (1s,15-150 keV; ph/cm^2s)	0.4	0.4



- 2 Coded Mask / CZT detectors





NGC4051
Krongold et al 2009

Back up slides

Observing programme

Table 2: Observing program for a 5-year mission

CORE PROGRAM	Fields	ks/target	Total [ks]
GRBs	400	50	20,000
Cluster Formation (10^o x 10^o)	100	50	5,000
Clusters (1Ms on source+1Ms bg)	10	2000	20,000
WHIM 4.5^ox4.5^o	25	1000	25,000
Auxiliary Science			40,000
Total (5 years)			*110,000*

HARI

Table 7: HARI instrument requirements

Parameter	Requirement	Goal
Resolution at 0.5 keV	80 eV	70 eV
Resolution at 5.9 keV	150 eV	130 eV
Field of View (diameter)	1.4°	1.5°
Energy range [keV]	0.3 – 5.0	0.2 – 10.0
Effective area @ 1 keV	530 cm^2	1000 cm^2
Effective area @ 6 keV	25 cm^2	100 cm^2
Angular resolution (HPD)	15 arcsec	10 arcsec
Time resolution	0.5 s	0.1 s
Peak count rate [c/s]	10,000	30,000
Instrumental background @ 1 keV [cts/cm^2/s/keV]	1.5×10^{-3}	6×10^{-4}

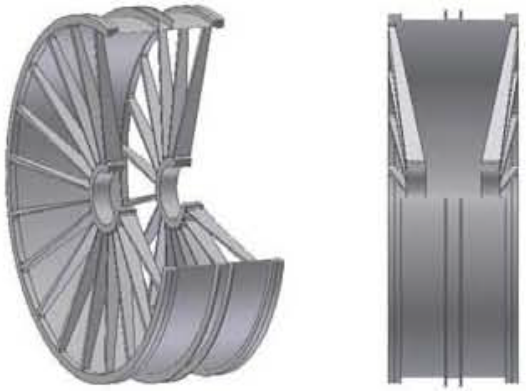
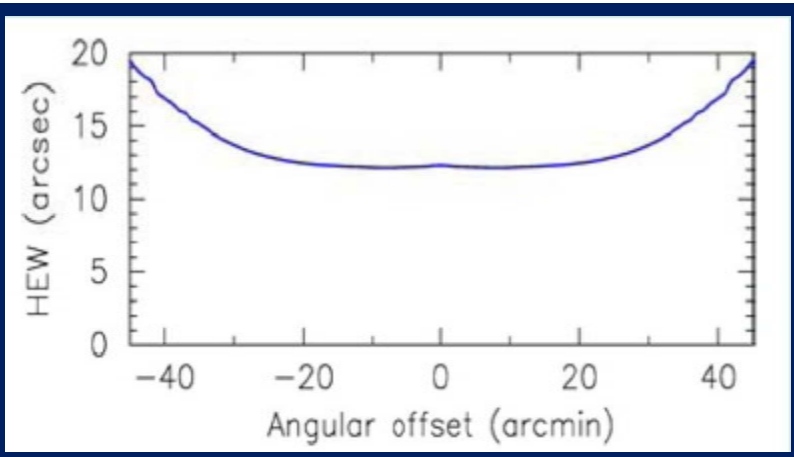
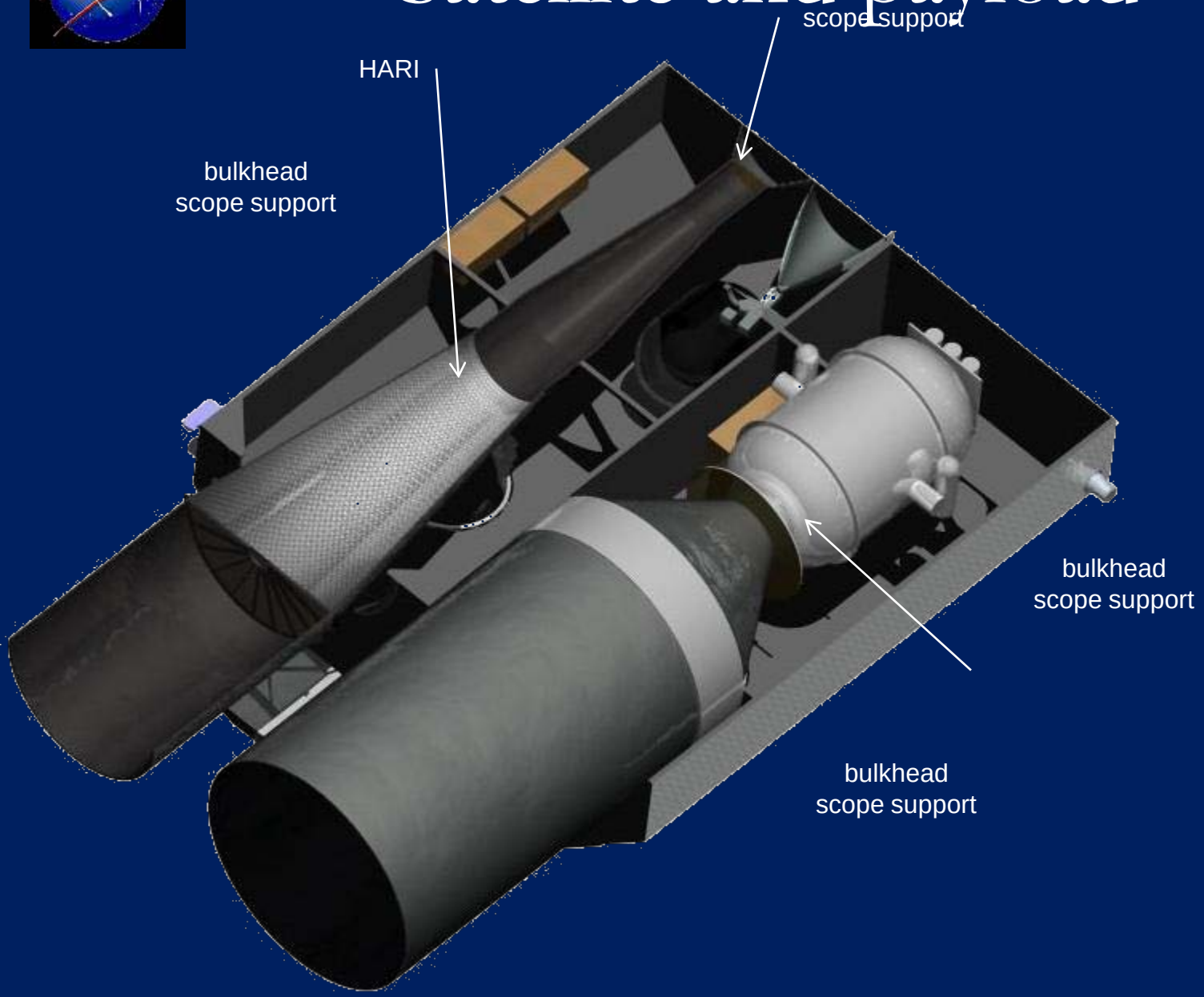


Figure 8: Wide-field X-ray optics design.

- Mirror: Polynomial profile with constant PSF
- CCD



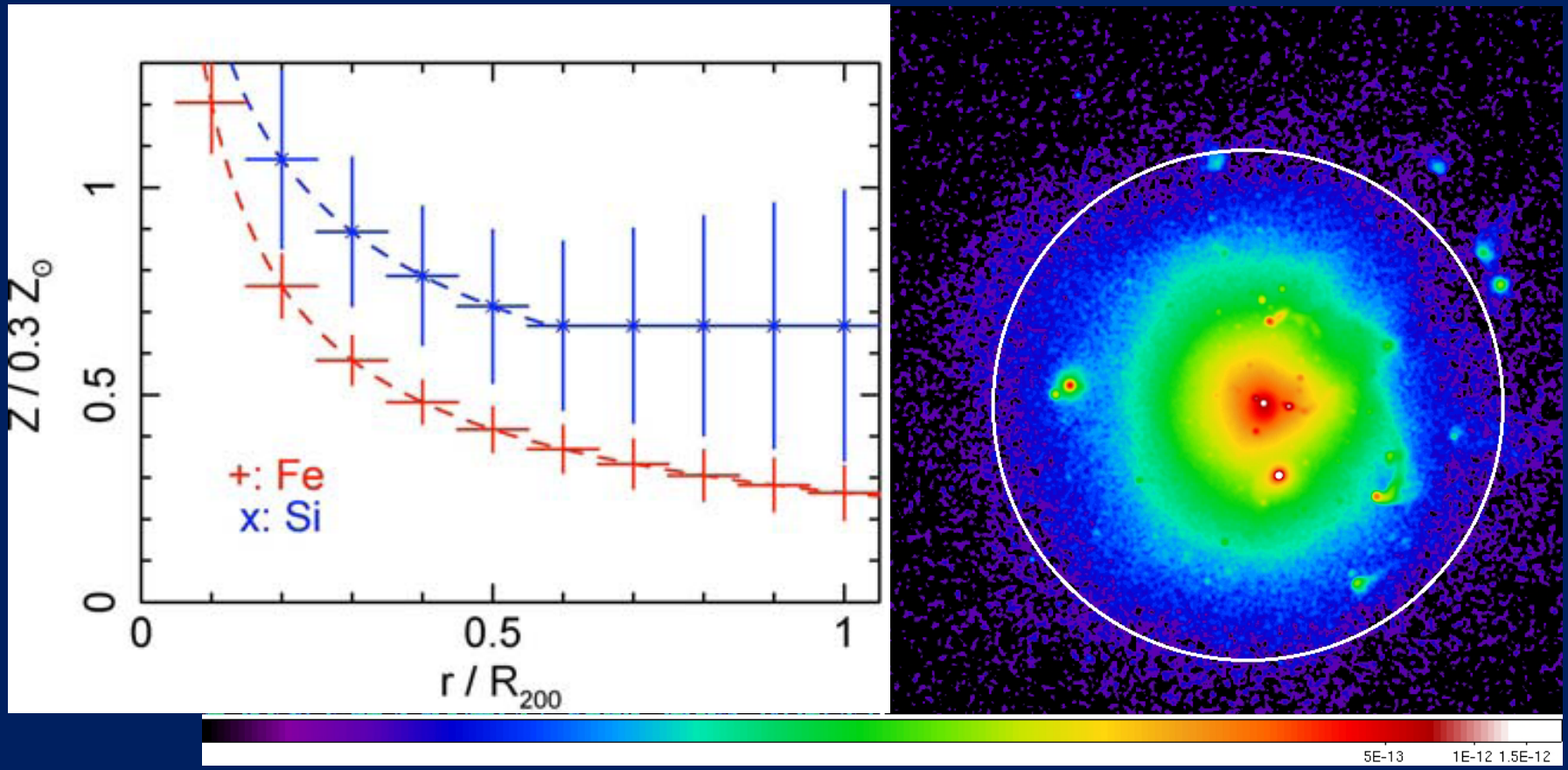
Satellite and payload



Back to the Future

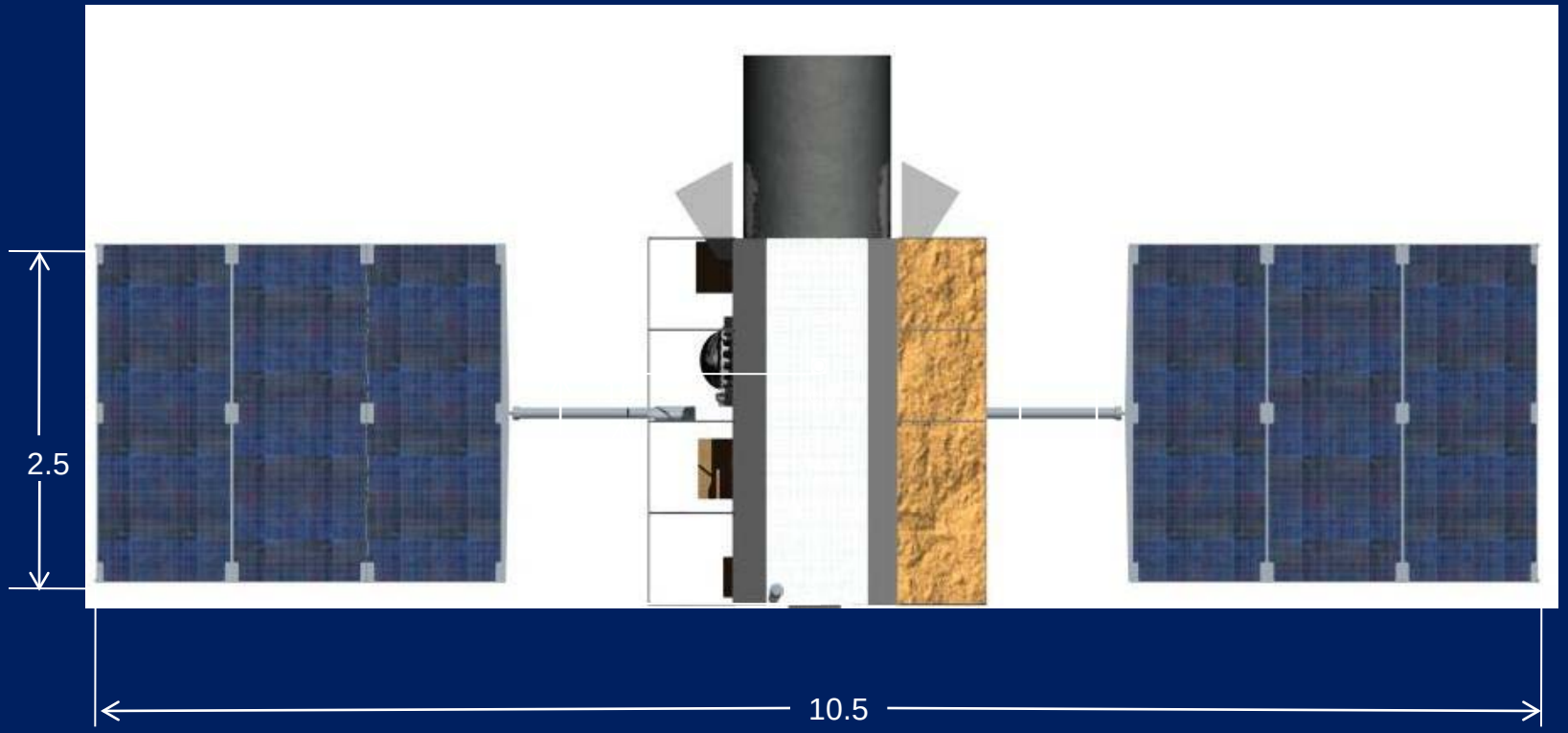
- Future X-ray missions based on new generation of Transition Edge Sensor microcalorimeters (<2 eV resolution)
- International X-ray Observatory (IXO) - Xenia
- Exciting drivers addressing cosmology in X-rays

Tracing clusters at virial radius



Configuration: Falcon Shroud

Configuration



Evolution of the Universe

Past

Structure formation

Present

Reionization

Stars

Galaxies

Clusters

WHIM

Small scale

GRBs

SNRs

Starburst galaxies/ AGNs

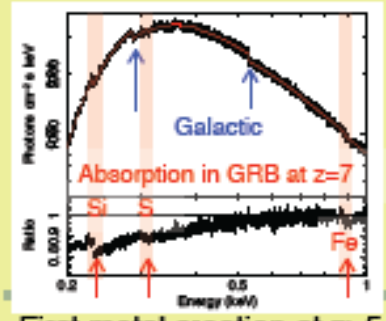
Clusters

WHIM

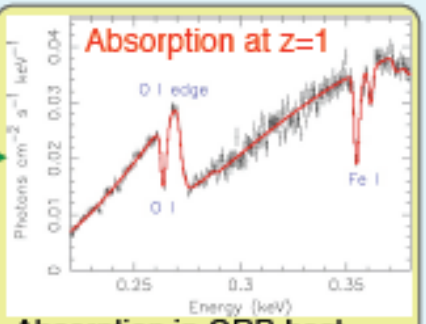
Large scale

Feedback & Enrichment

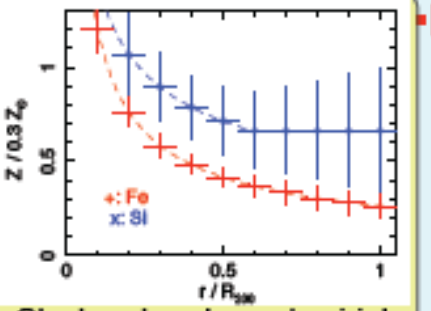
XENIA



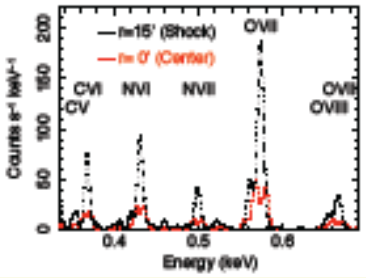
First metal creation at z>5



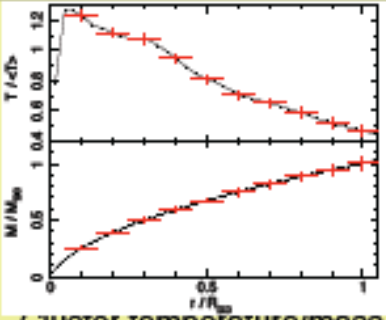
Absorption in GRB host galaxies



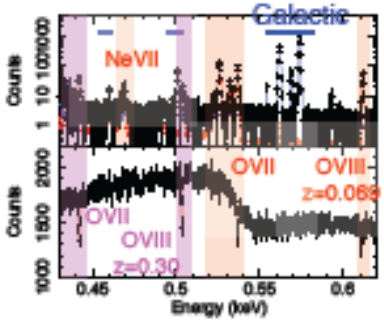
Cluster abundance to virial radius



Metal creation/injection by super novae



Cluster temperature/mass study to virial radius



Missing baryons at low redshift

EDGE/XENIA

Cosmic chemical evolution of baryons

L. Piro
on behalf of the EDGE/XENIA collaboration

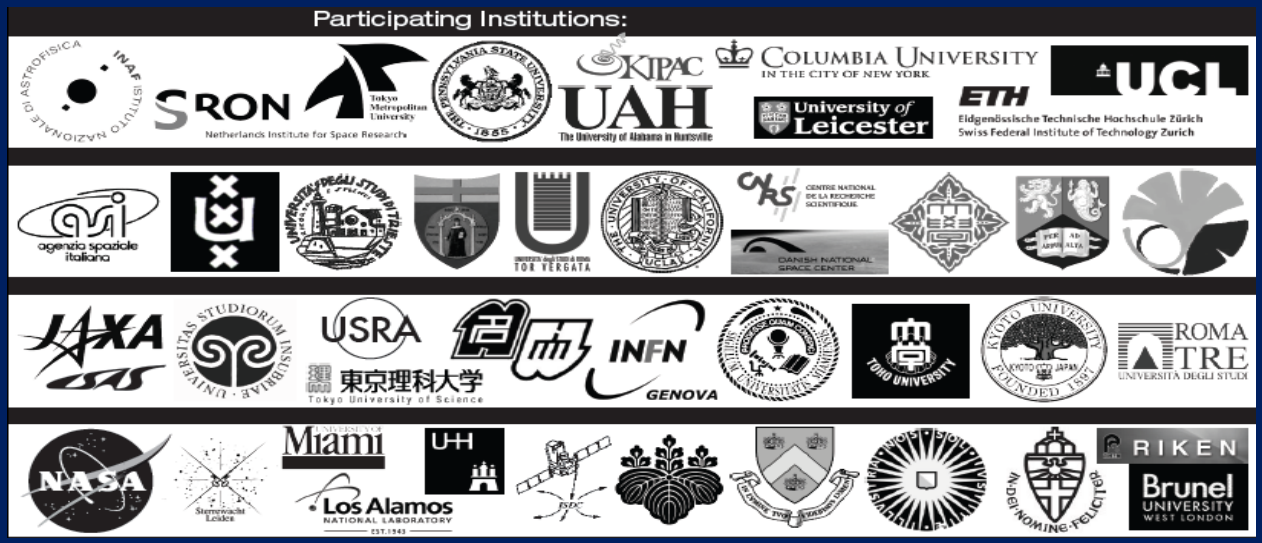
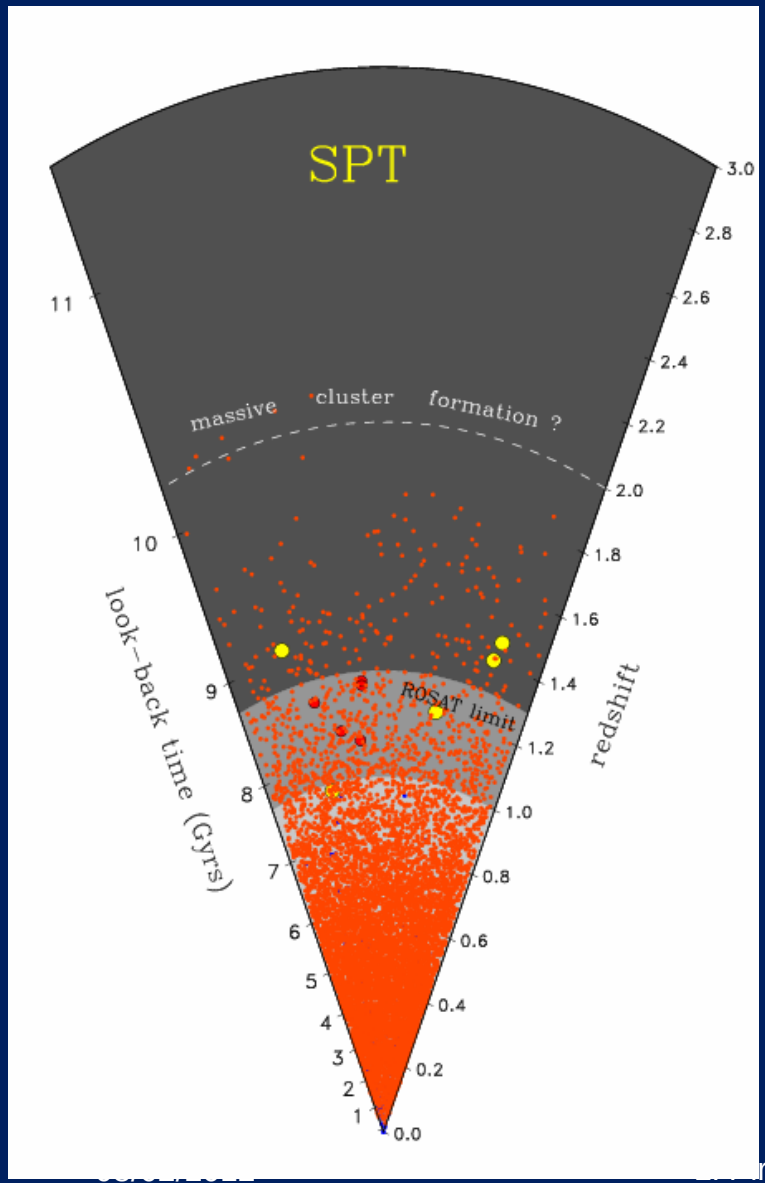


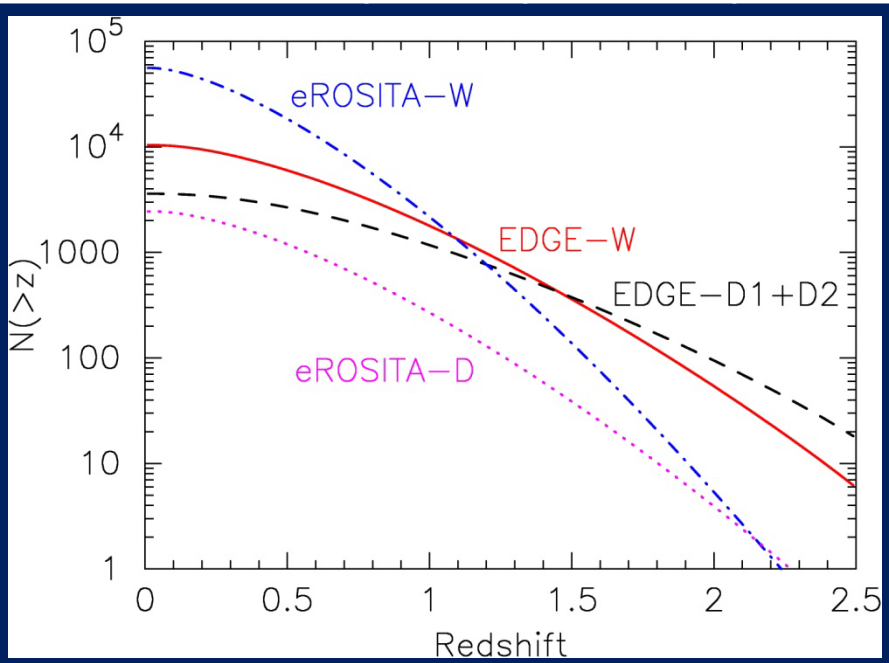
Table 1: Estimated number of absorption systems detected at >5σ per year by Xenia [4]

Fluence 0.3-10 keV [erg cm^{-2}]	# GRBs [yr^{-1}]	EW$_{min}$ O VII [eV]	EW$_{min}$ O VIII [eV]	# O VII/VIII [yr^{-1}]
>1 10^{-5}	6	0.12	0.08	19
>5 10^{-6}	13	0.18	0.12	29
>2 10^{-6}	33	0.28	0.19	37

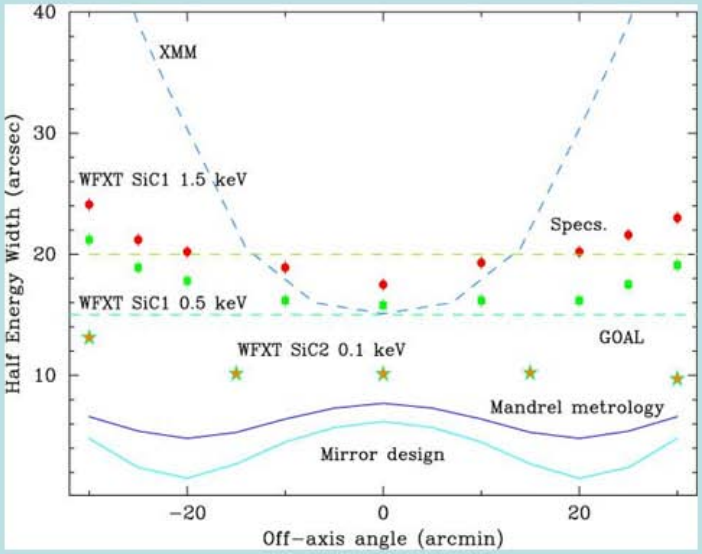
Cluster evolution

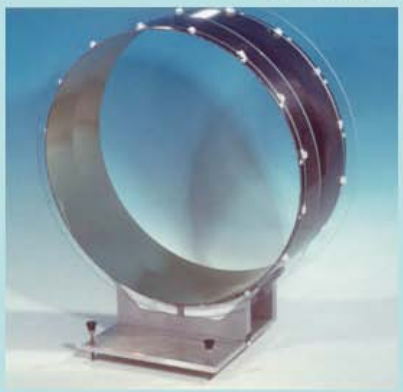


Survey	Wide	Deep-1	Deep-2
Exposure	50 ks	1 Ms	2 Ms
Total area (deg^2)	340	11.5	8
Clusters @ z>1	1800	510	600
Clusters, T_X @ z>1	450	140	170



WFImager: polynomial optics





WFXT (epoxy replication su carrier in SiC) – Ø = 60 cm

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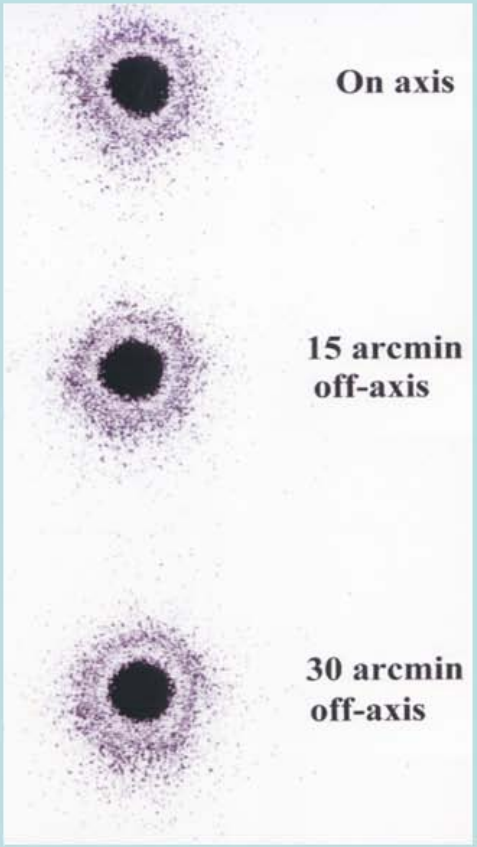
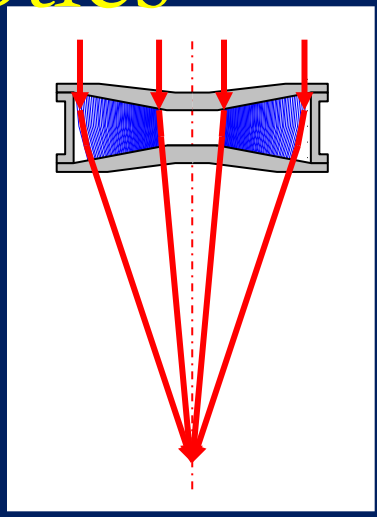
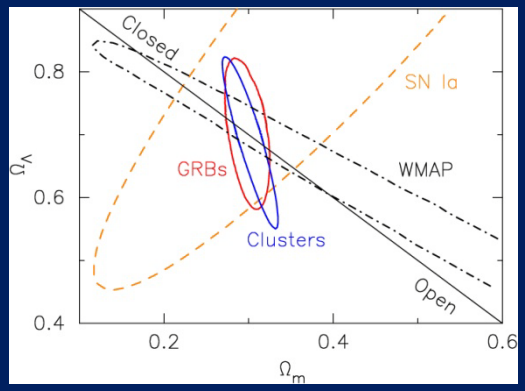


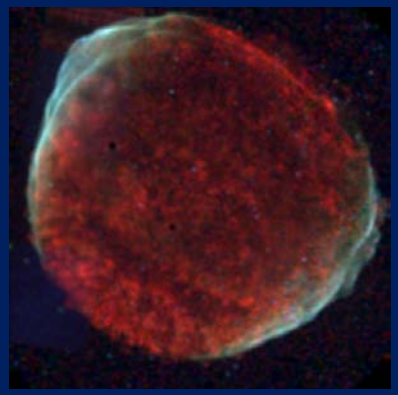
Test @ Panter-MPE

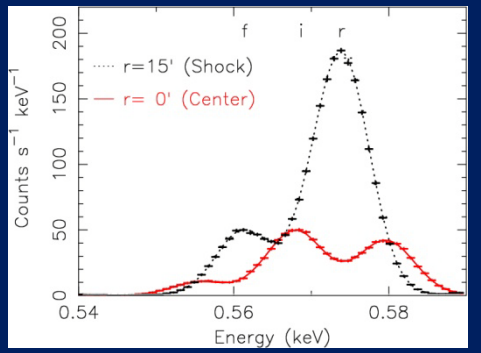


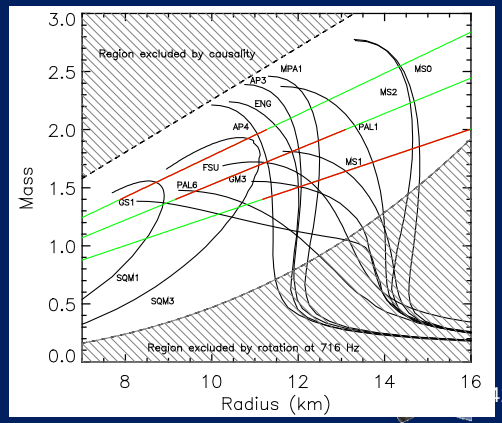
Auxiliary Science

- Cosmological parameters (Clusters & GRBs)
- Feedback processes
- AGN
- Physics and Progenitors of GRBs
- The densest matter
- Violent accretion on compact objects
- Stars
- Solar system
- Search for light Dark Matter (sterile neutrinos)
- Gravitational waves from SMBH mergers



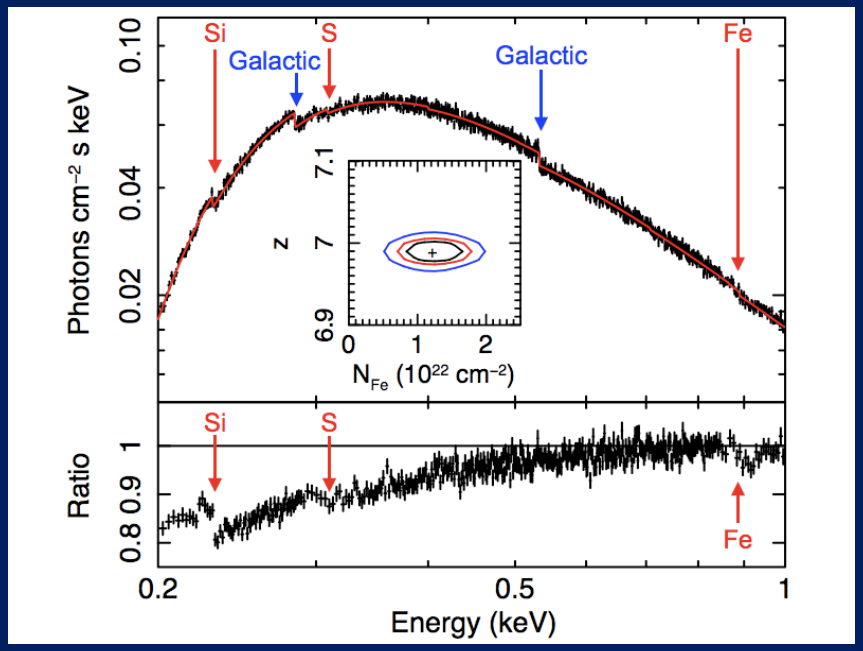






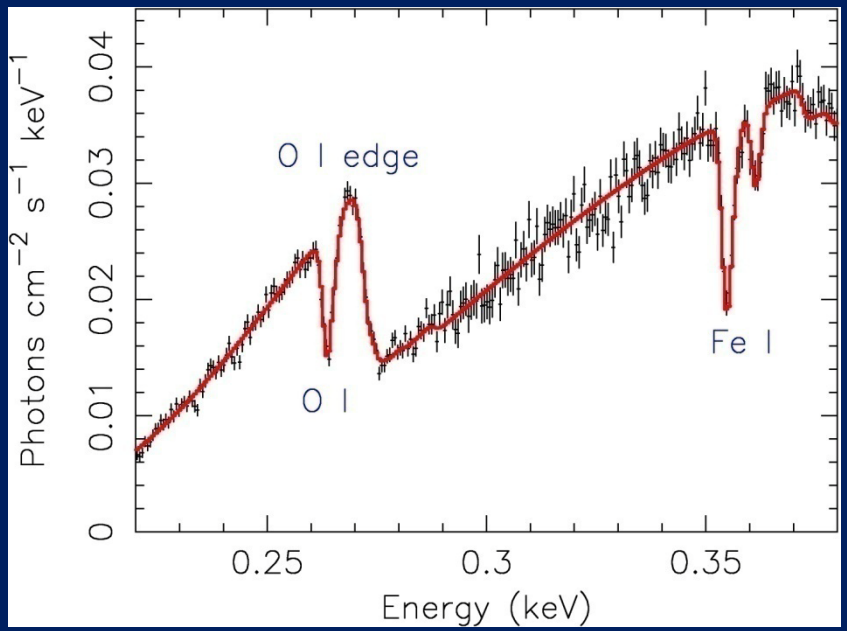
Metal and ISM evolution with GRB

Metal enrichment in the environment of massive stars upto z>6



X-ray metal edges from a GRB nearby environment at z=7

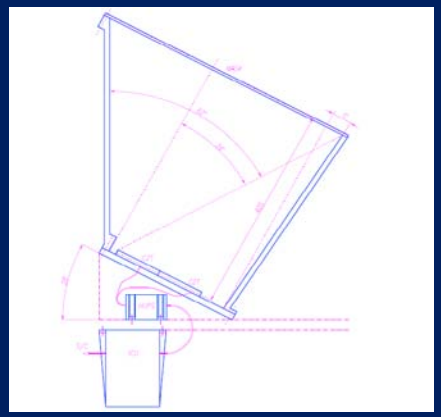
ISM of the host galaxy, kinematical studies of the outflows

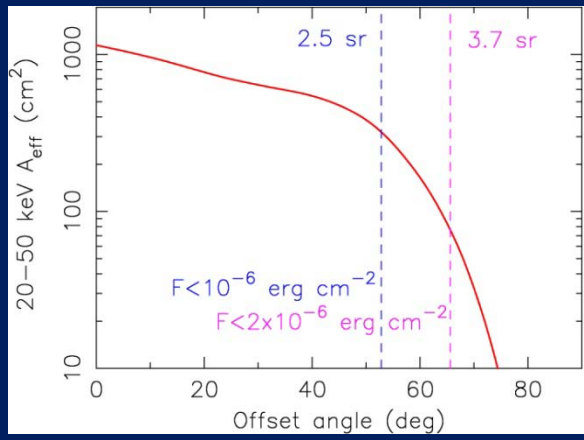


Resonant absorption lines from GRB host galaxy at z=1

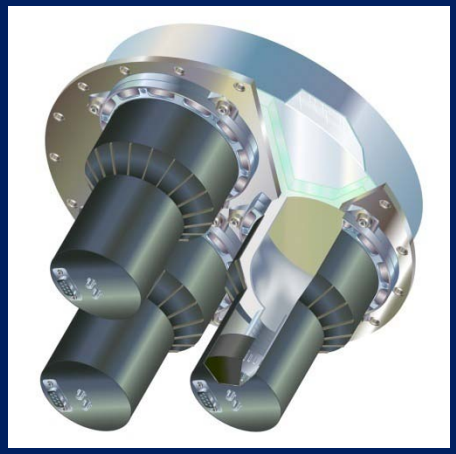
Payload I

- **WFM →**
  coded mask, CZT detector



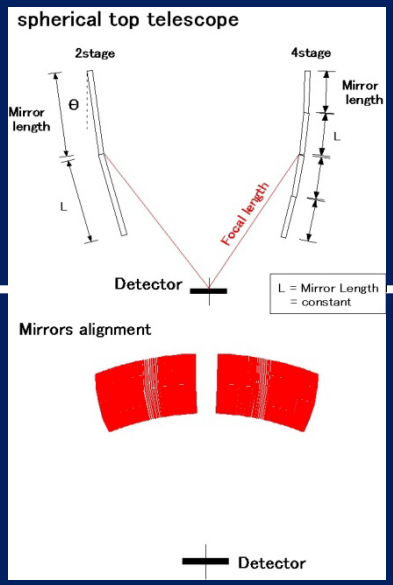


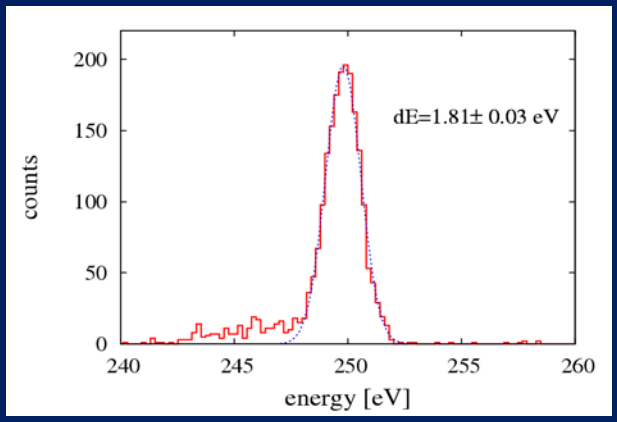
- **GRBD**
  2 scintillators (NaI)

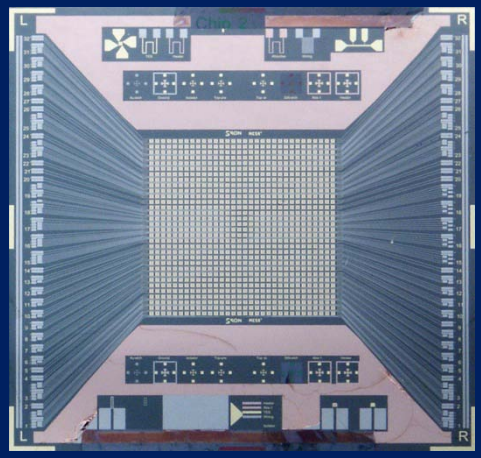


Payload II

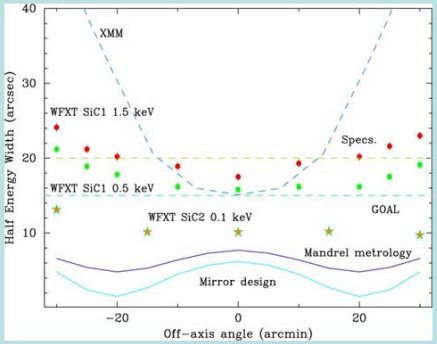
- **WFS**
  2/4 fold →
  TES calorimeter

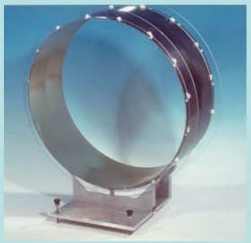






- **WFI →**
  polinomial,
  CCD





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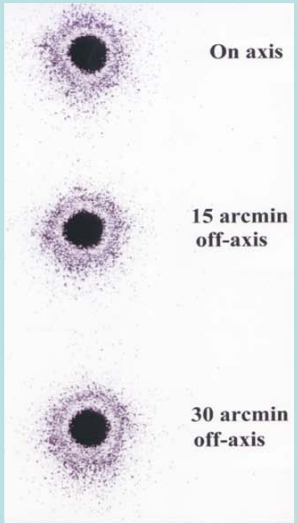
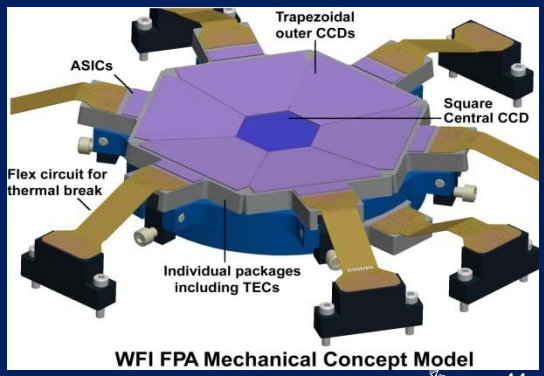


Test @ Panter-MPE

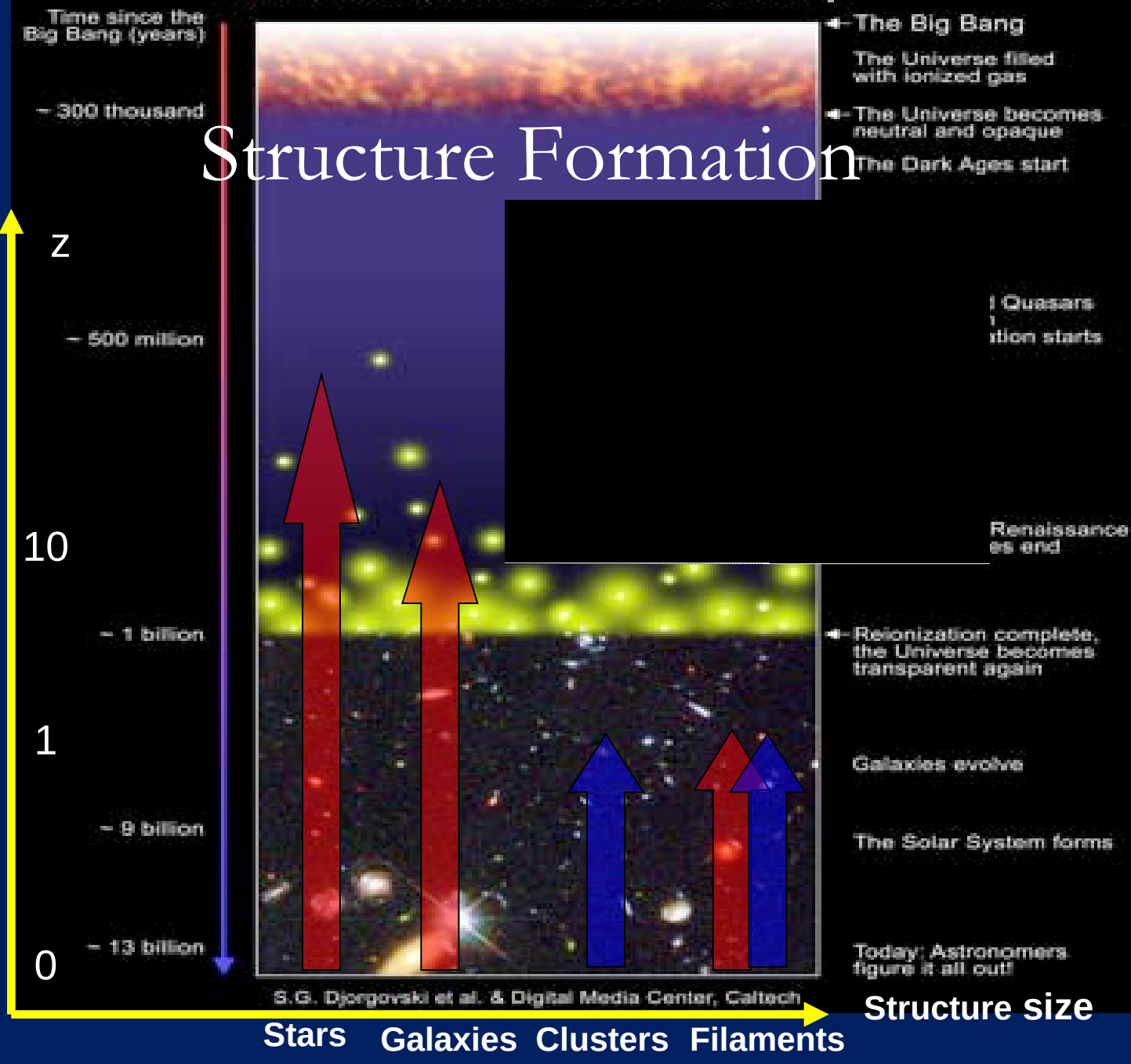


HOW ?

Most of the baryon of the Universe are locked in large scale, low density structures visible only in X-rays

High resolution spectroscopy and spatial resolution, wide field in emission

GRB as cosmological beacons: fast reaction, high res. absorption spectroscopy

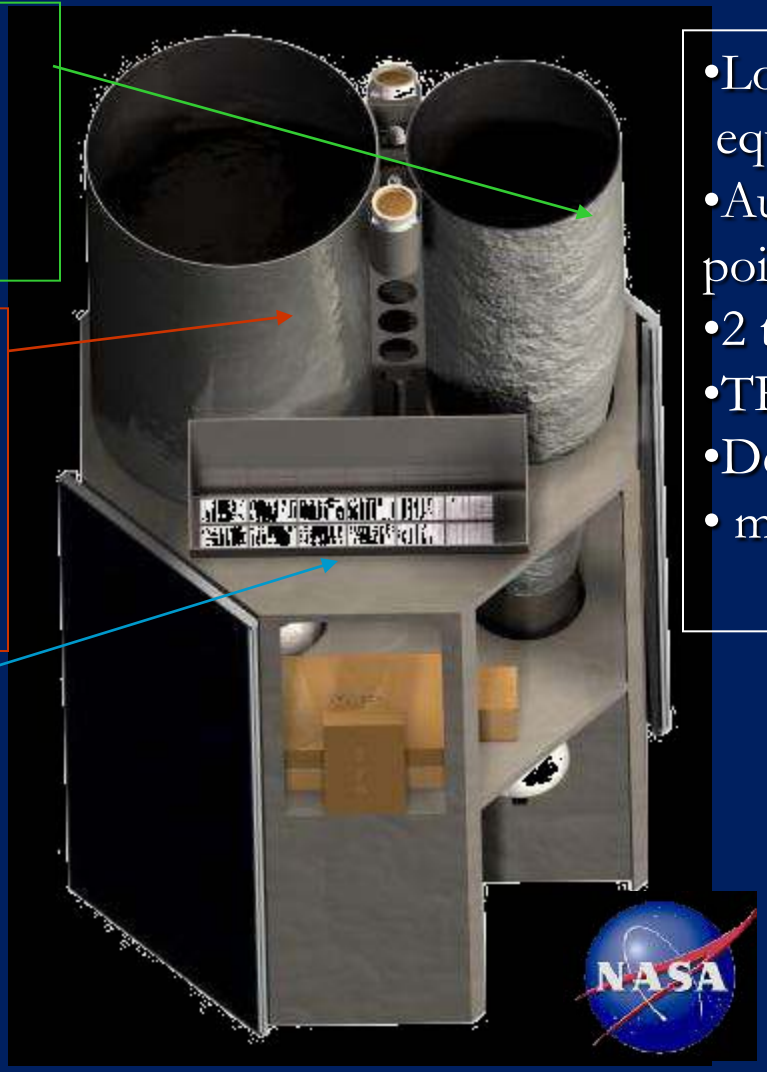


XENIA: Mission and Payload

HARI: High Angular Resolution Imager
1000cm^2@1keV 0.3-8 keV CCD
Field=1.4° ang.res=10" constant

CRIS: Cryogenic Imaging Spectrometer
1000cm^2@0.5keV
0.1-3 keV TES DE<2.5eV
Field=1.0° ang.res=3'

TED: Transient Event Detector
¼ of the sky, 3' localization
8-200 keV



- Low bkg: LEO equatorial
- Autonomous fast pointing in 60 s
- 2 tons
- TRL≥4
- Decadal Survey
- medium size